
# TPC/HBD R&D at BNL

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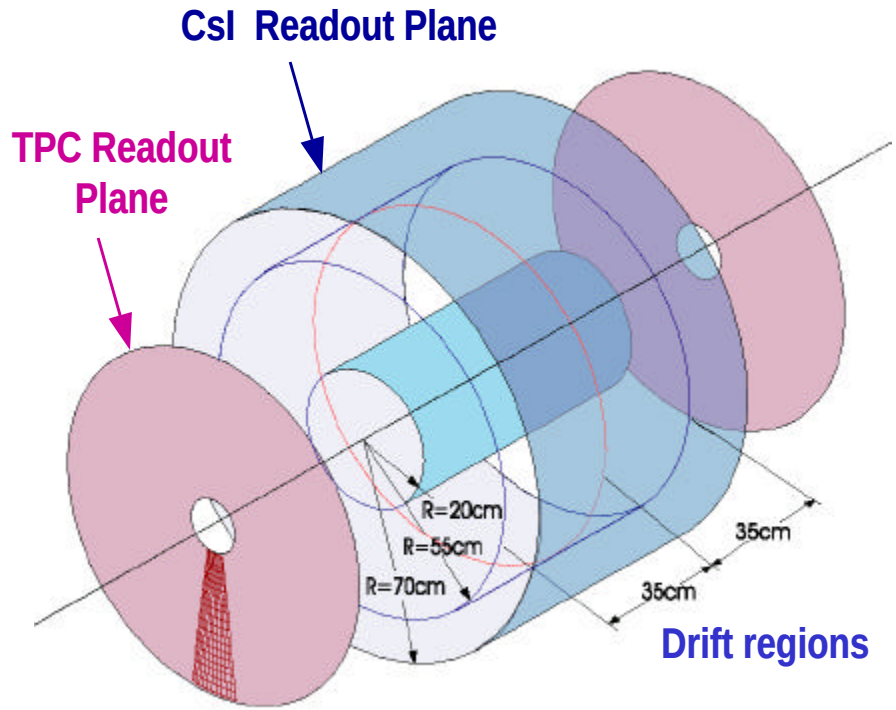
BNL

Mini Workshop on PHENIX Upgrade Plans
August 6, 2002

# TPC/HBD Detector




**GEMs are used for both TPC and HBD**

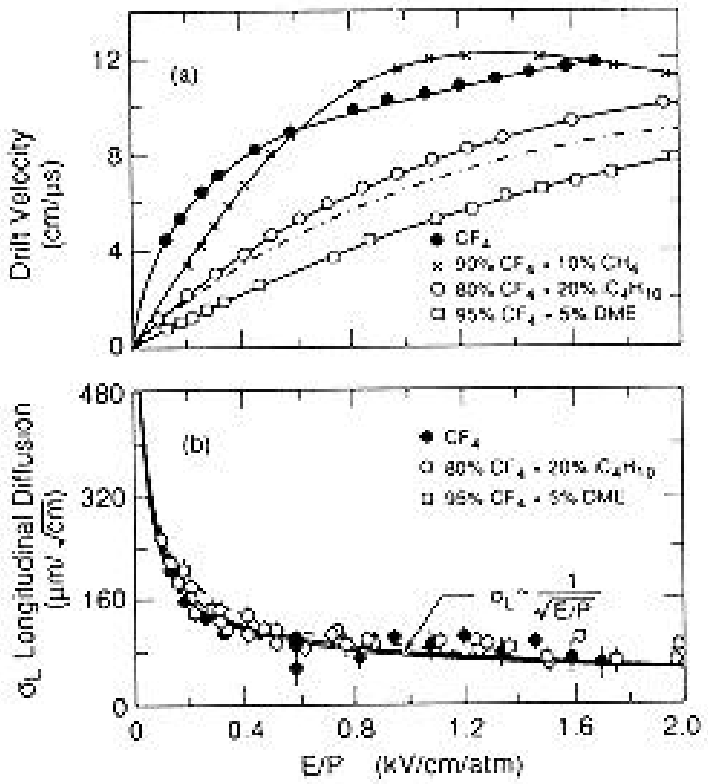
- **Fast, compact TPC**
  **R<70 cm, L< 80 cm, $T_{drift} \leq 4$ msec**
- **Serves as an inner tracking detector in both HI and pp, providing tracking through the central magnetic field**
  $D\phi = 2\pi, |\eta| \leq 1.0$
  $Dp/p \sim .02p$
- **Provides electron id by dE/dx**
  **$\Rightarrow$ e/p separation below 200 MeV**
- **HBD is a proximity focused Cherenkov detector with a ~ 50 cm radiator length**
- **Provides minimal signals for charged particles**
  **$\Rightarrow$ "Hadron Blind Detector"**

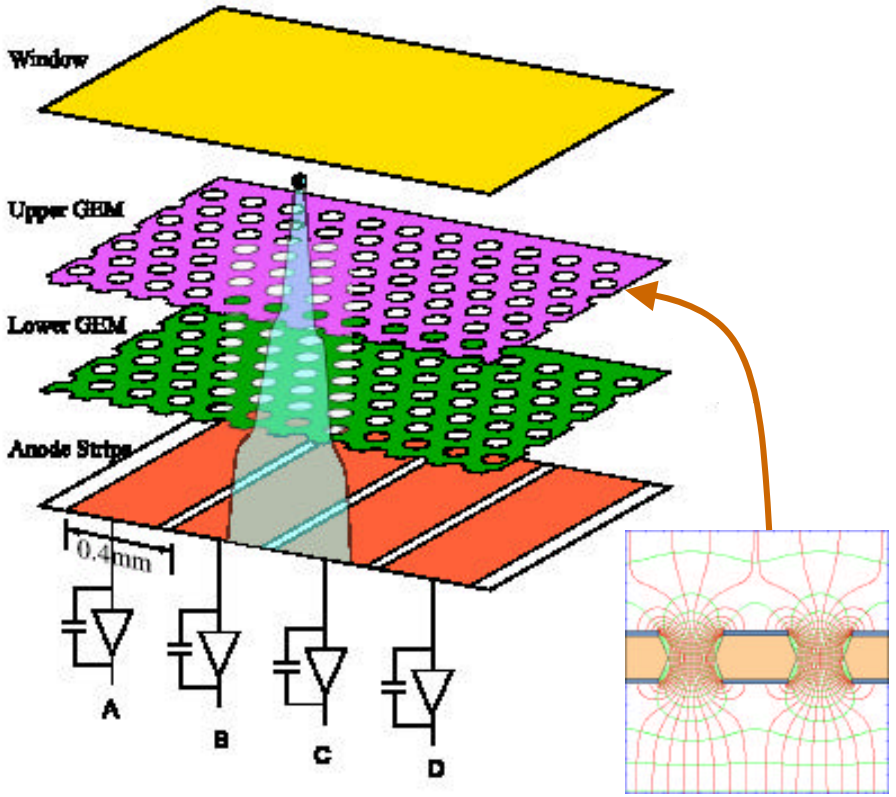
# R & D Issues

- Performance of micropattern detectors
  - **Stability and gain uniformity**
  - **Gas studies ($CF_4$, $CH_4$, $C_2H_2$ + mixtures)**
    - **Drift velocities, drift lengths, diffusion parameters, dE/dx, ion feedback,…**
    - **Optical transmission extending down into the VUV ( $\Rightarrow$ impurities)**
    - **Photocathode (CsI,..) studies (in combination with GEMs)**
    - **Scintillation light ( I and decay time)**
- Detector component design
  - **TPC & HBD readout planes**
  - **TPC field cage + HBD electrodes**
  - **Understand E x B effects for drifting charge in non-uniform magnetic field**
  - **Understand space charge effects (do we need gating ?)**
  - **Construction of prototype**
- Electronics ( $\rightarrow$ P.O'Connor, Chi)

# GEM Spatial Resolution

J.Va'vra et.al., NIM A324 (1993) 113-126




**Diffusion Limit**

**$s_L \sim 80\ mm/\sqrt{35cm} \Rightarrow \sim 500\ mm$**

# TPC Channel Count and Data Volume

DR = 1 cm, RD f = 2 mm

$\Rightarrow$ 80K readout channels (40K/side)

10 cm/ms $\Rightarrow$ 100 mm/ns

20 ns (50 MHz) digitizing $\Rightarrow$ Dz = 2 mm

4 msec/20 ns $\Rightarrow$ 200 samples (8 bits)

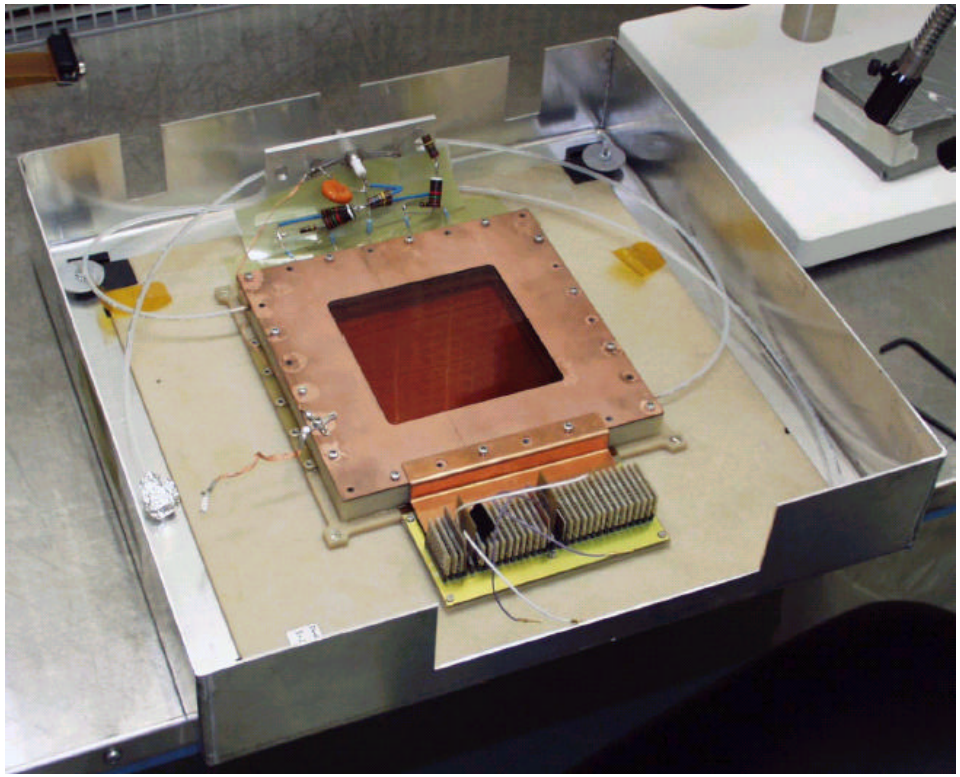
80K x 200 bytes = 16 MB

Zero suppression (1/20) $\Rightarrow$ 800 KB

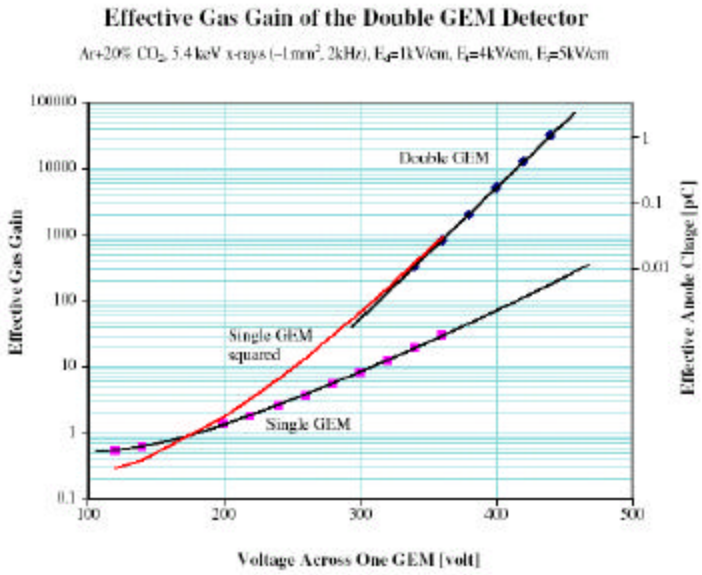
800 KB/40 msec $\Rightarrow$ 160 Gbit/sec

160 x 1Gbit fibers vs 16 x 10 Gbit fibers

# GEM Detector Studies

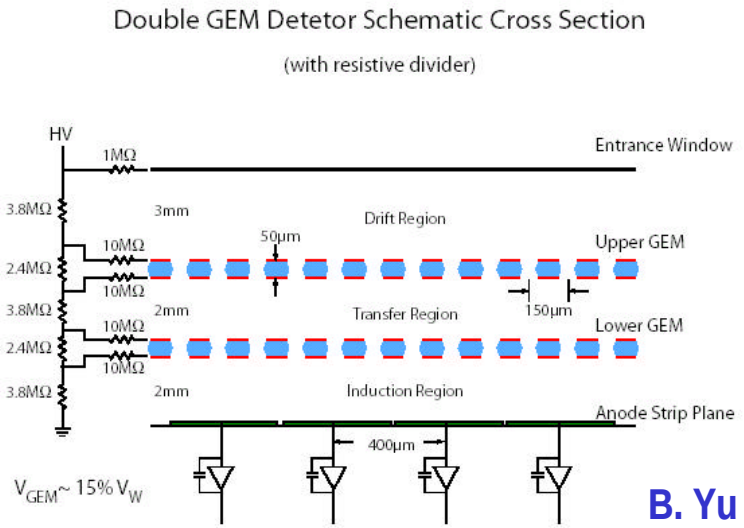


**Double GEM from F. Sauli at CERN**

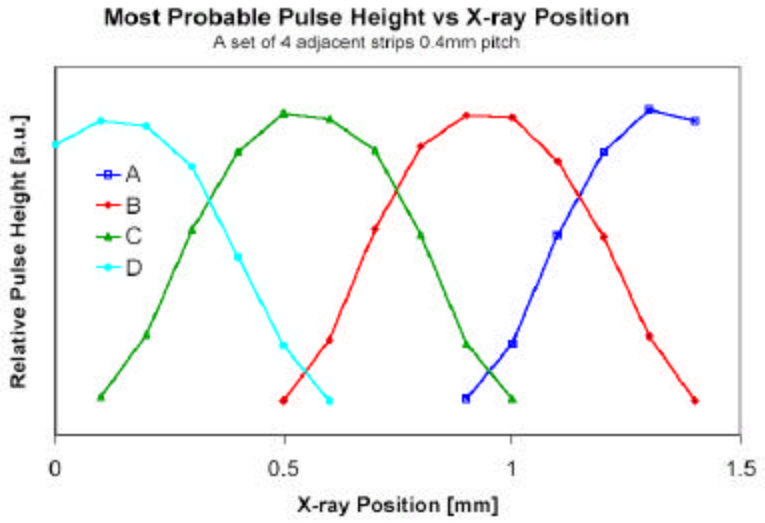


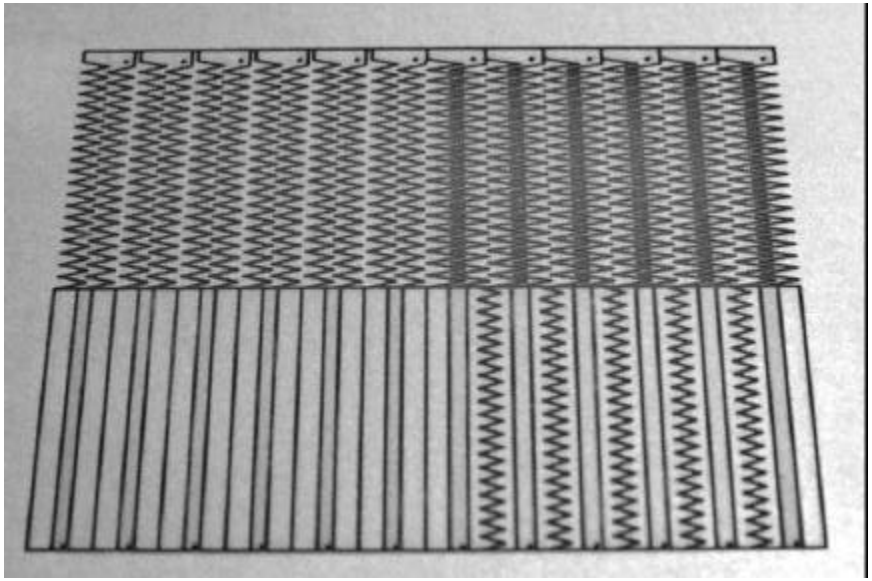

**Data from Bo Yu, BNL Instrumentation Div.**

# Readout Plane Design




B. Yu



## Charge Interpolation Methods

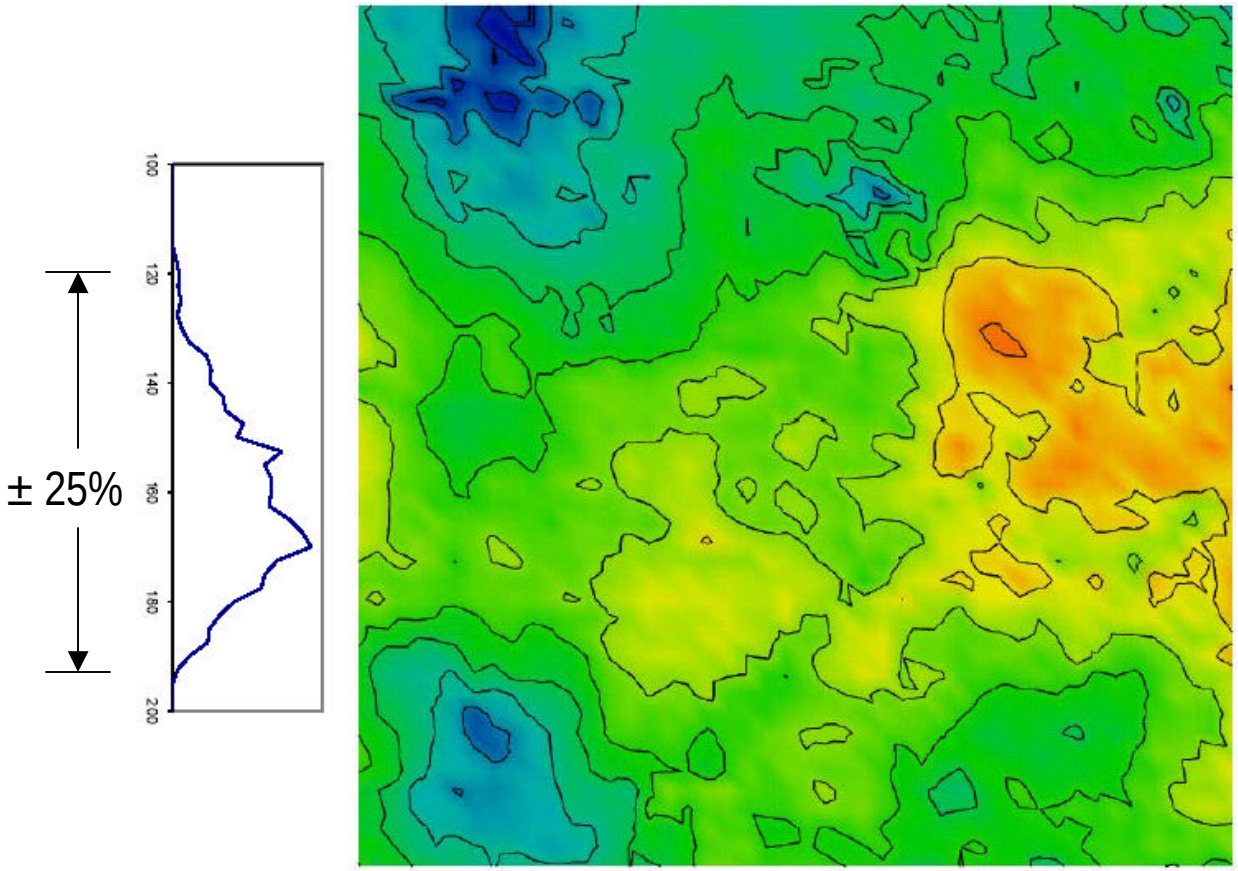
**Chevrons**

**Floating strips**

**Resistive layer**

# Gas Gain Uniformity

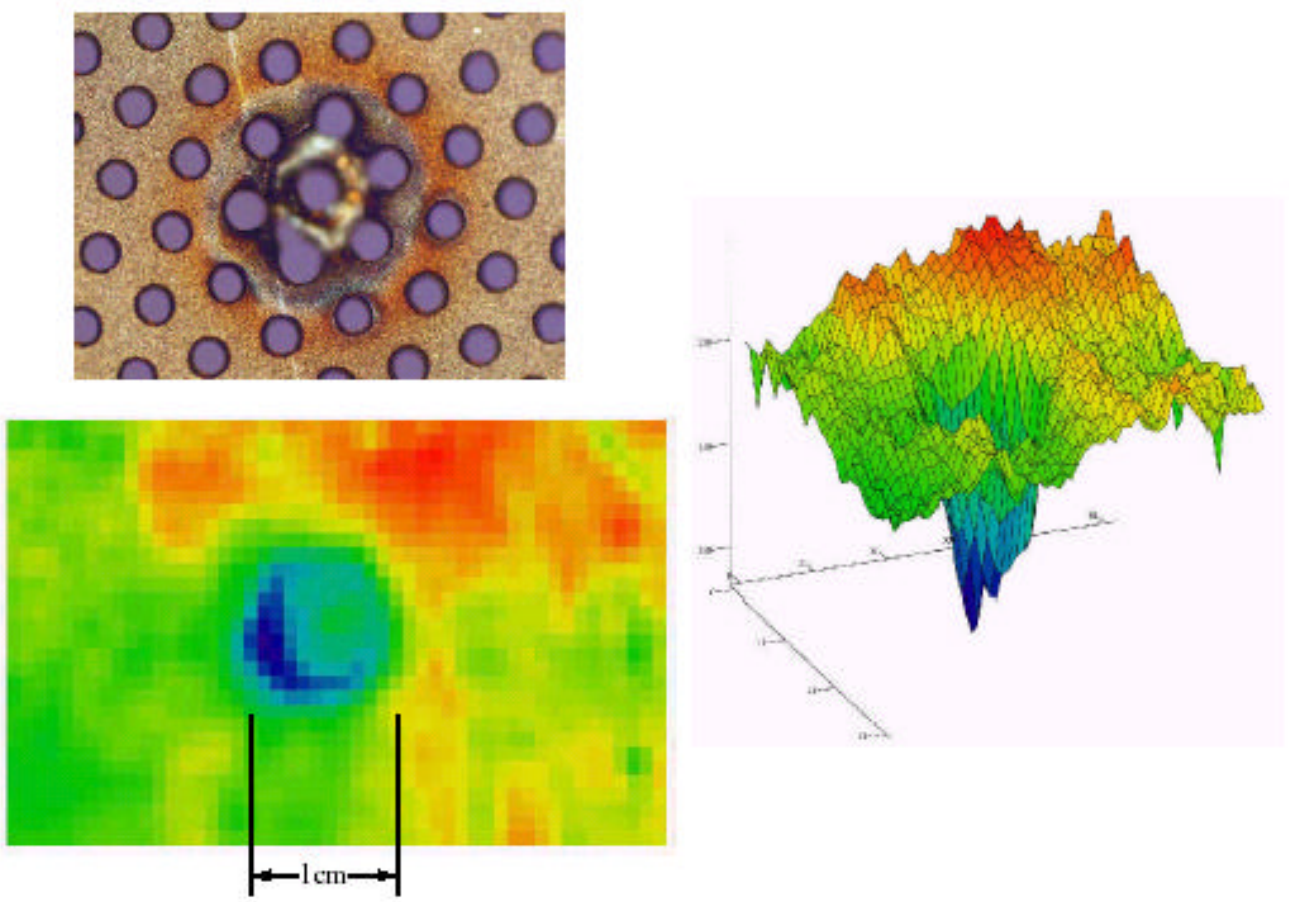
Double GEM Collimated 5.4 keV X-ray, at 2mm x 2mm grid, 9cm x 9 cm area




**B.Yu**

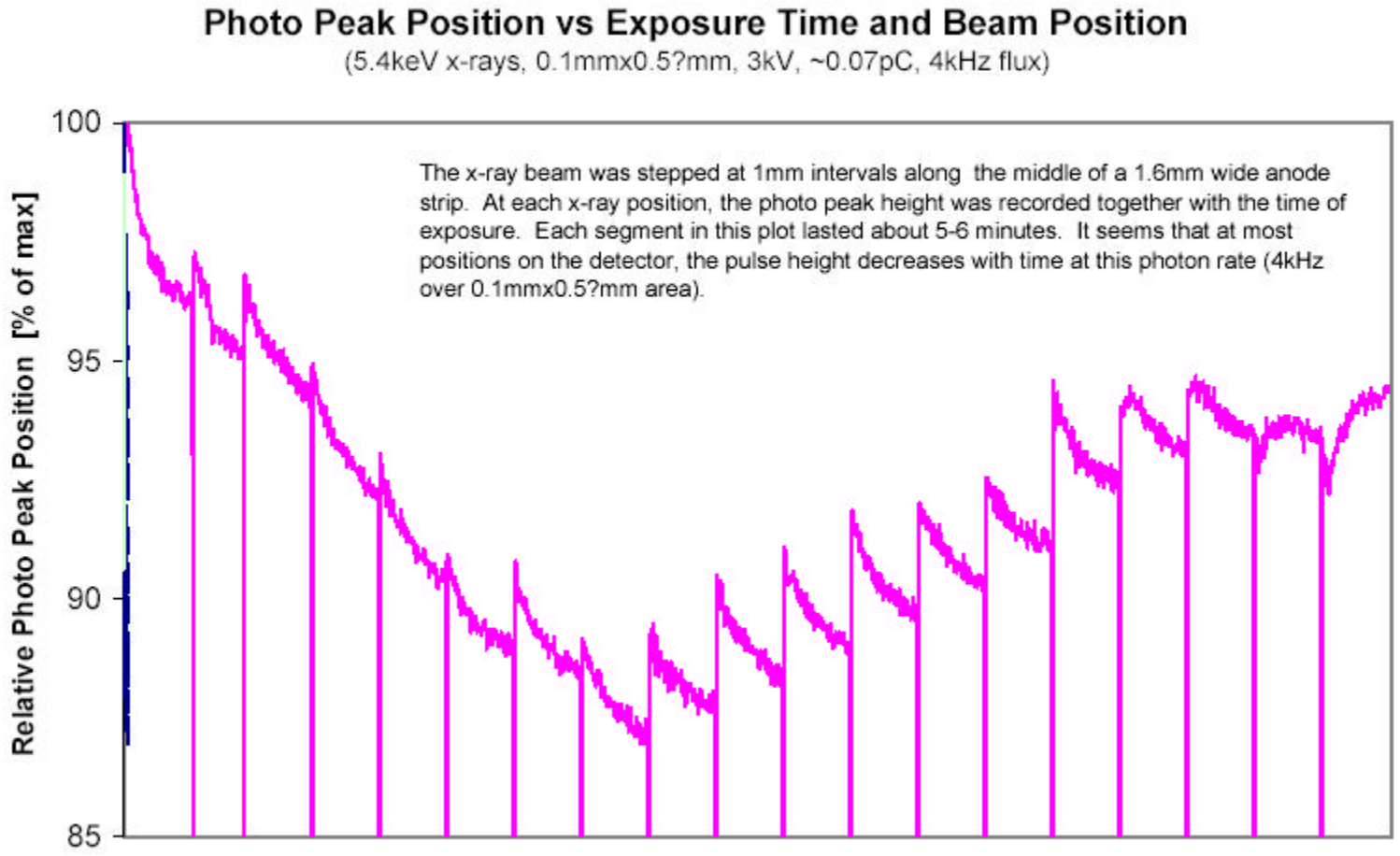
# Damage Caused by Discharges

**Gas Gain Variation around a Damaged Spot**



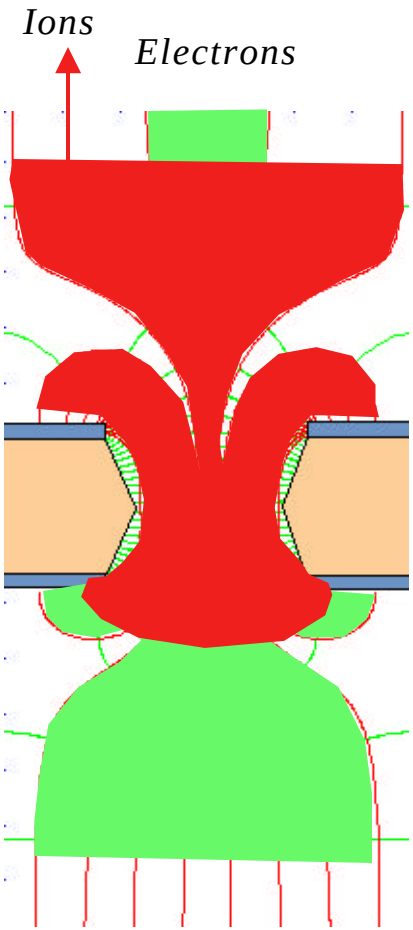

B.Yu

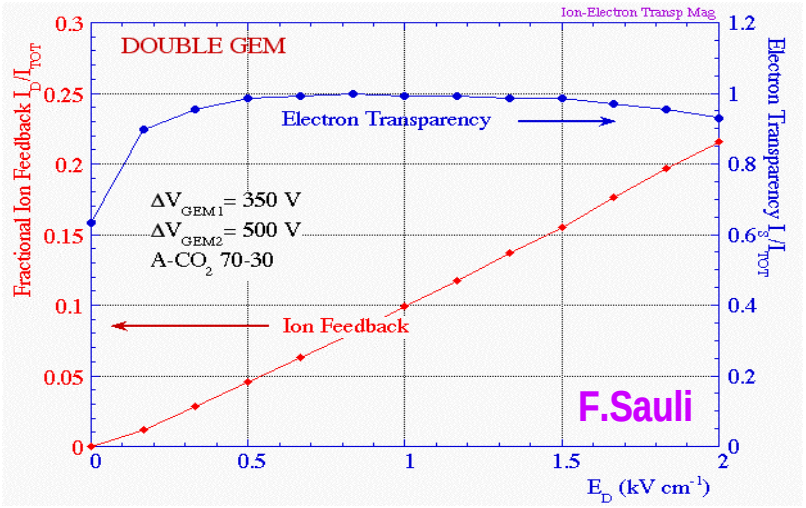
# Position Dependence and Rate Effects

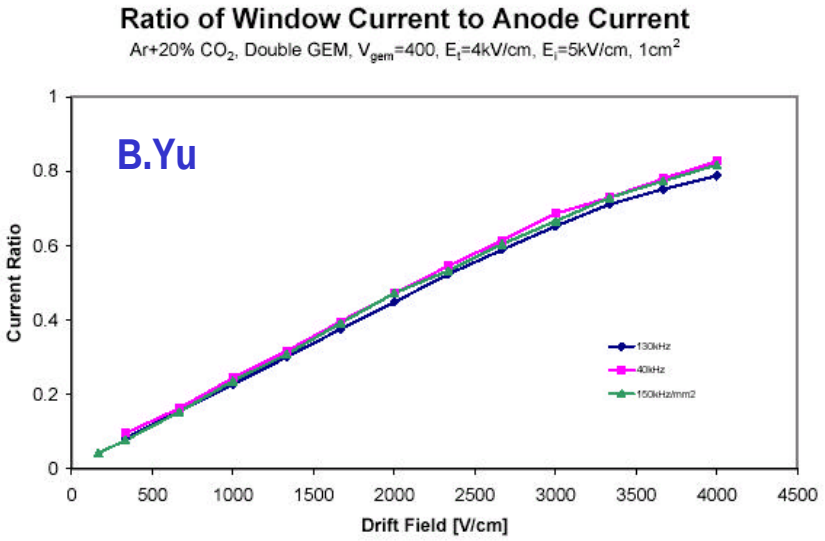



**B.Yu**

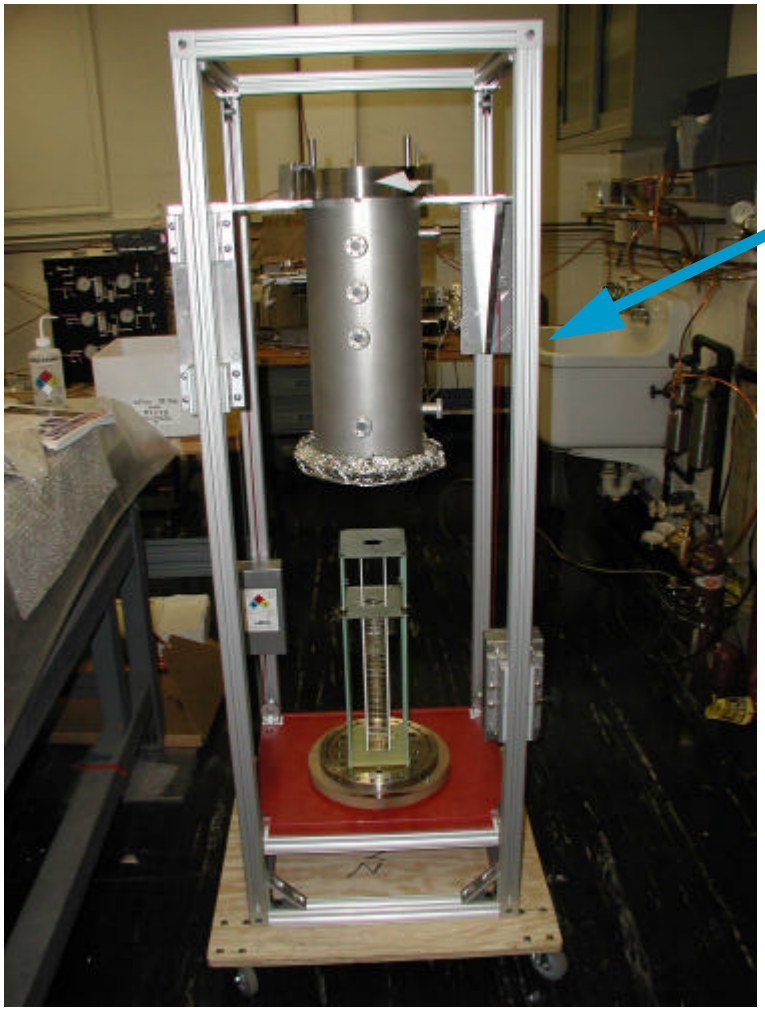
# Ion Feedback in GEMs



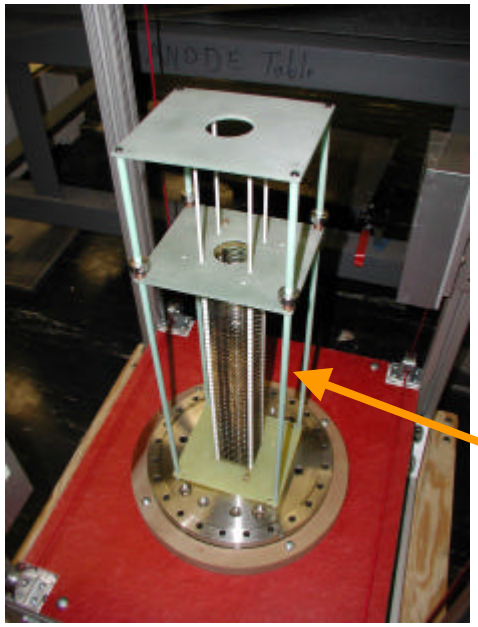



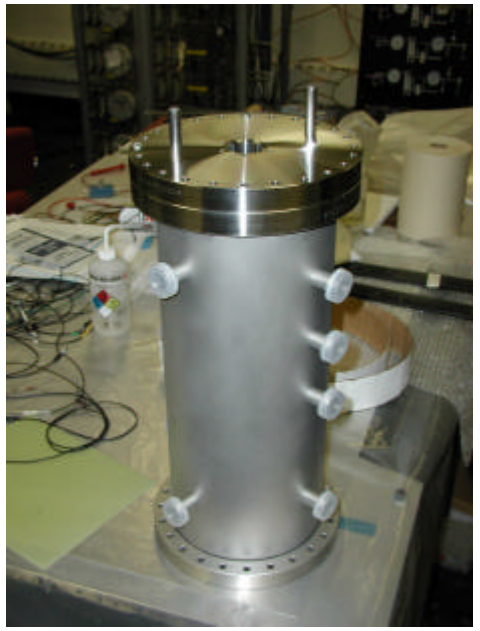



# Test Drift Cell



Lifting Fixture



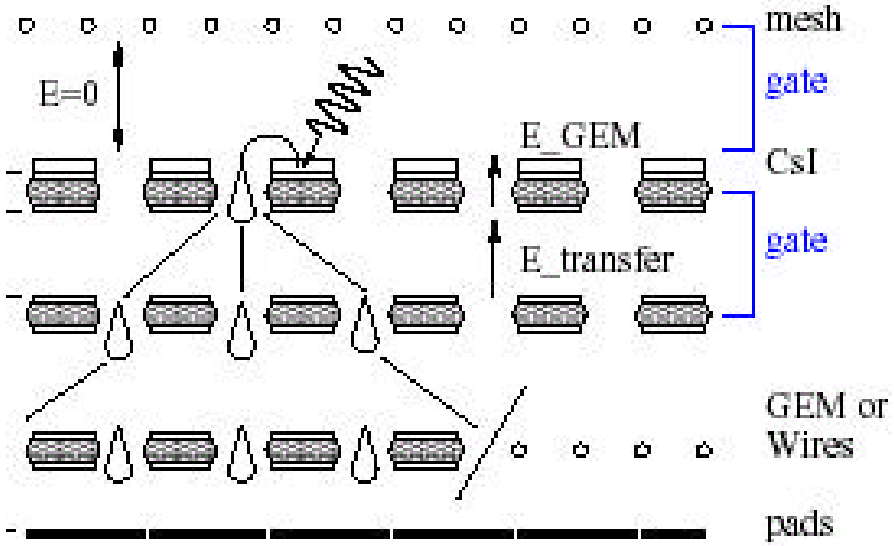


Vacuum Chamber

Drift Stack

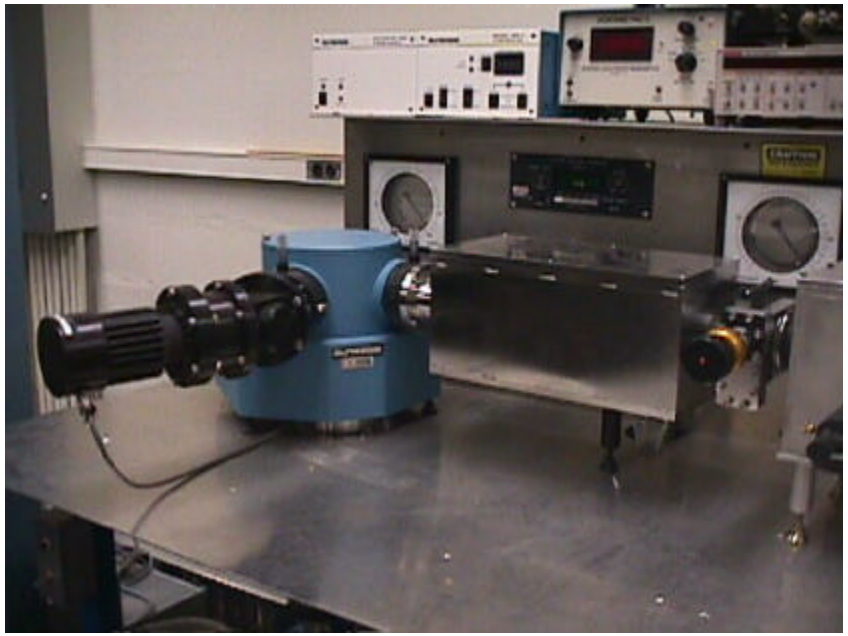
# GEM with CsI Photocathode

- CsI photocathode deposited on outer GEM foil (must deposit Ni+Au on GEM foil)
- Multistage GEM used to detect ~ few photoelectons
- Higher gain, larger segmentation of readout plane

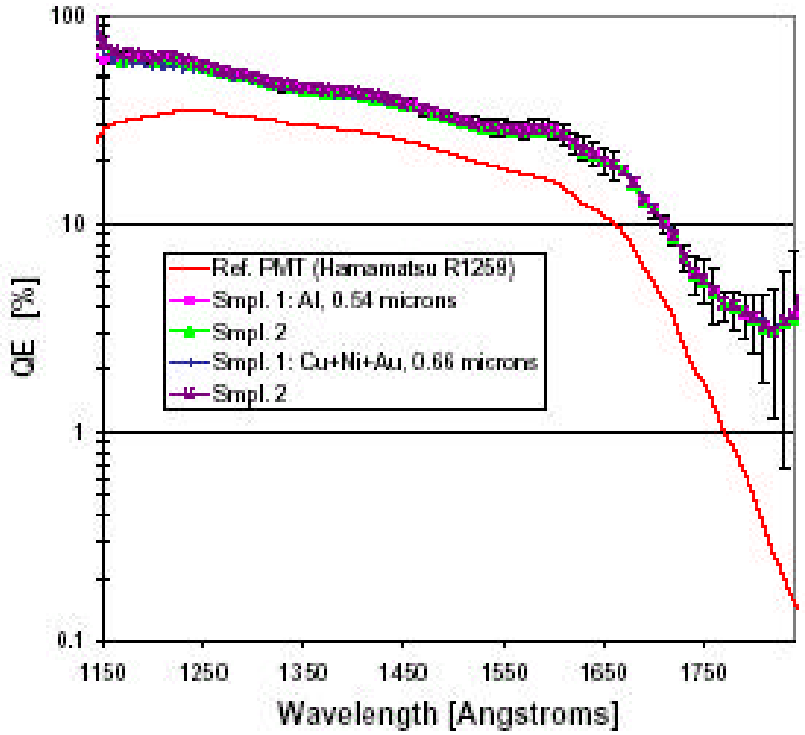



**Is the HBD really "hadron blind" ?**

# CsI Photocathodes



**Quantum efficiency of CsI photocathodes deposited on metal surfaces**

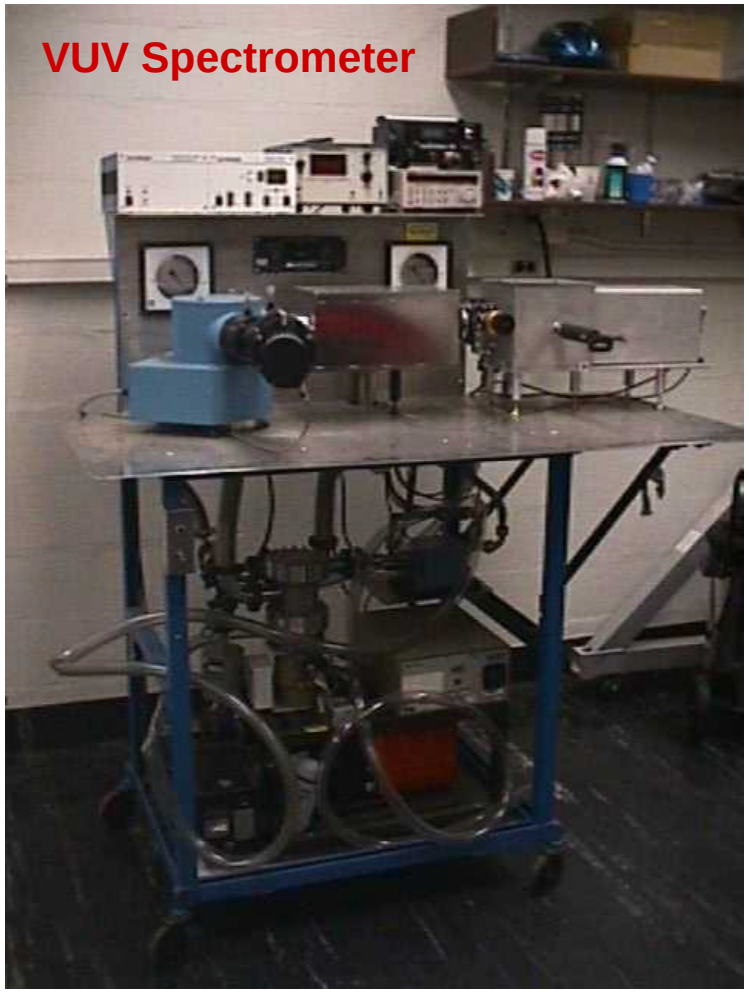



**VUV Spectrometer is used as a light source**

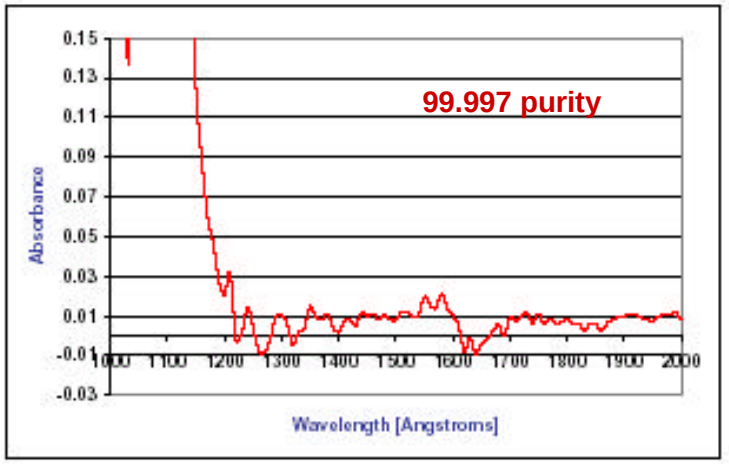
**Calibrated CsI PMT is used as a reference**

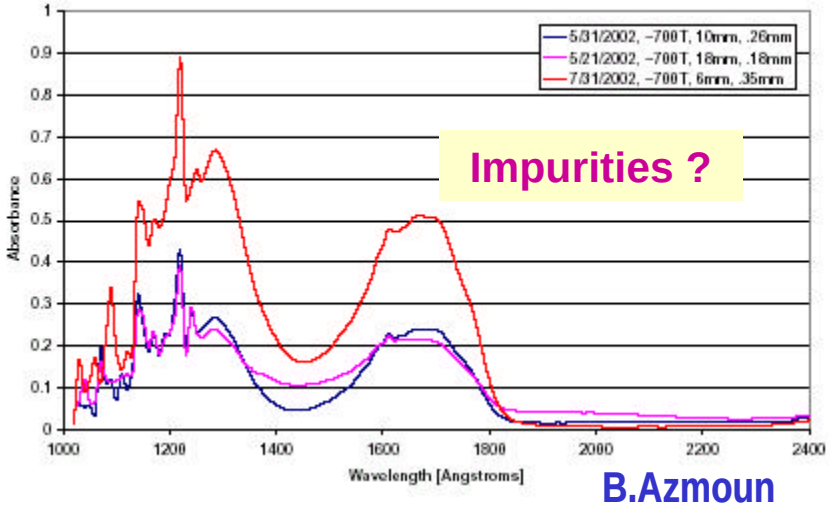
**B.Azmoun**

# Study of Optical Properties of Gases




## Absorbance of $CF_4$




B.Azmoun

# Future R&D Plans

## FY2003

- Complete TPC drift cell (including readout plane)
- Gas studies with TPC, HBD, GEMs, (MicroMegas ?)
- Photocathode studies with CsI (CVD diamond ?)
- Design TPC field cage and HBD electrode structure
- Begin engineering design study of TPC/HBD detector system
- Begin design of HBD & TPC readout electronics

## FY2004

- Build and test TPC/HBD prototype detector
- Complete design of HBD readout electronics
- Complete engineering design of TPC/HBD detector system

## FY2005

- Complete TPC detector design
- Complete design of TPC readout electronics

# Cost and Schedule

## R&D (3 years)

- HBD Detector Design: $250K
- TPC Detector Design: $750K
- Electronic Design: $1.5M (5 FTEs x 3 yrs)

**Total: $2.5M**

(LDRD for $100K in FY 2001 & FY 2002)

## Construction (3 years)

- Detector: $250K
- Gas System: $250 K
- Detector mounted electronics: $4.0M
  (80K Readout Channels @ $50/ch)
- Other readout electronics: $500K

**Total: $5.0 M**